University of Saskatchewan

EE 480.3 Digital Control Systems

Midterm Exam. February 10, 2003

Note: 2 hour open-book exam.

Instructor: K. Takaya

1. (35) Answer the following questions.

1. Find the z-transform of

$$y_1(k) = a^{k+1}u(k-2) \quad \text{where} \quad a > 0.$$

2. Find the starred transform $G^*(s)$ of

$$G(s) = \frac{1}{s(s+1)}$$

3. Draw a simulation diagram of the following system $G(z)$ in standard canonical form. Derive the state equation and output equation from the obtained simulation diagram.

$$G(z) = \frac{z^2 + 0.4z - 0.05}{z^2 - 0.7z + 0.1}$$

2. (35) A servo control system is shown in Fig. 2a, in which θ_r and θ are reference angle and actural angle, respectively. Fig. 2b shows the frequency response (Bode diagram) of this system showing a small phase margin of approximately 45°. Design a phase lead compensator, which increases the phase margin to 70°. The first order compensator is given by

$$G_c(s) = K_c \frac{s + s_z}{s + s_p}$$

where $s_z < s_p$. Allow 10° to account for an expected phase decrease due to the upward shifting of the new cross-over frequency. Determine K_c, s_z and s_p.

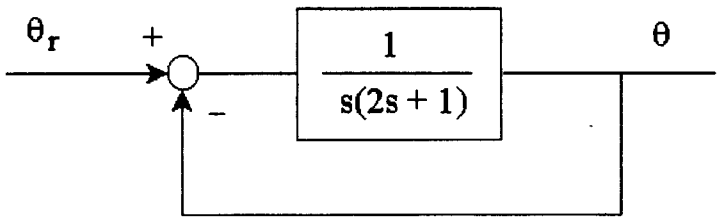

Fig. 2a Block diagram of an uncompensated control system

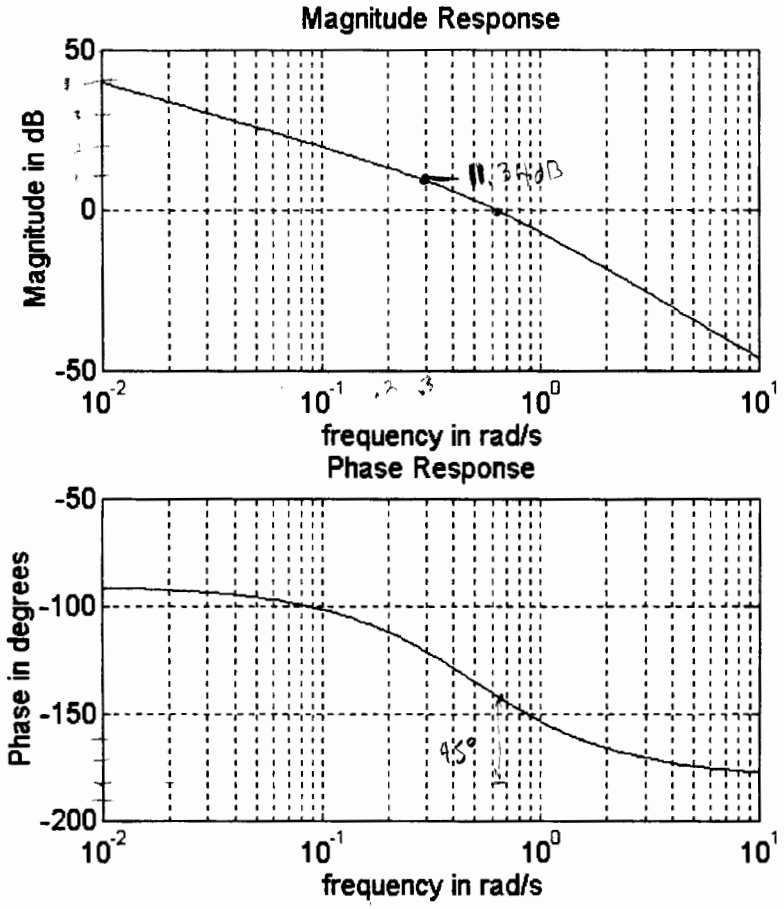

Fig. 2b Frequency Response of the Phase-lead Compensator

3. (30) Given a difference equation,

$$y(k) - y(k-1) + 0.16y(k-2) = x(k),$$

which produces output $y(k)$ from input signal $x(k)$,

1. Obtain the output sequence $y(k)$ for a unit step input $x(k) = u(k)$ and $y(k) = 0$ for $k < 0$ by using the z-transform.
2. Find the final value of $y(k)$, i.e. $y(\infty)$, then check if your solution for (1) agrees with the final value.

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